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Fecundity of the Striped Bass, *Roccus saxatilis* (Walbaum)

ROBERT M. LEWIS AND RUPERT R. BONNER, JR.

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INTRODUCTION

Investigators of striped bass long have needed a method for the quick and reliable estimation of the number of mature ova released by a spawning population. Jackson and Tiller (1952) counted the eggs in striped bass from the Chesapeake Bay area and showed the relation of egg number to weight, length, and age of the fish. They did not, however, make a statistical comparison to determine which of these attributes most accurately indicated the number of mature ova produced. The objective of the present study was to find an easily measured feature, such as weight, length, or age, that constitutes a good index of fecundity.

During spring spawning runs in the Roanoke River, North Carolina, we collected 159 female striped bass from the commercial catch; 12 in 1958, 17 in 1960, and 130 in 1963. To reduce the possibility of their being partially spawned, we used only fish caught below the spawning area as they moved upstream. The fork length and weight of each fish were measured to the nearest 0.1 inch and 0.1 lb. The ovaries were preserved in 7 to 10% formalin. Ages were determined later by counting the number of annuli on plastic impressions of the scales. If no annulus was present at the edge of the scale, a "virtual" annulus was added. For example, fish that had four annuli and had completed another year's growth were assigned to age-group V.

DISTRIBUTION OF MATURE OVA WITHIN AND BETWEEN OVARIES

Spawning by an individual striped bass probably is completed within a few hours. Mature ova must therefore be positioned within an ovary so as to permit their release over a short period of time. Thus, accurate estimation of the number of these ova is aided by some knowledge of their actual distribution within an ovary.

Scofield (1931), working with striped bass on the West Coast of the United States, and Merriman (1941) and DeArmon (unpublished), who studied the same species on the East Coast, found mature ova uniformly distributed throughout both ovaries. To determine if this was also true for striped bass from the Roanoke River, we counted only ova that would have been released during the current spawning season. These were mature,

TABLE 1.—*Estimated mean number of mature ova (thousands) by age-group and body weight in striped bass from the Roanoke River, North Carolina, during April and May 1958, 1960, and 1963*
[Values in parentheses are the numbers of specimens upon which the mean values are based. These numbers do not total 159 because the weight of 1 fish and the lengths of 12 fish were not recorded. Sixteen fish could not be aged]

Body weight (pounds)	Age-group									
	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
2.0–2.9	130 (2)	231 (1)	–	–	–	–	–	–	–	–
3.0–3.9	251 (8)	–	–	–	–	–	–	–	–	–
4.0–4.9	328 (29)	295 (3)	345 (1)	–	–	–	–	–	–	–
5.0–5.9	401 (21)	458 (4)	289 (1)	–	–	–	–	–	–	–
6.0–6.9	390 (3)	436 (4)	586 (2)	–	518 (1)	–	–	–	–	–
7.0–7.9	–	422 (3)	622 (2)	548 (1)	–	–	476 (1)	–	–	–
8.0–8.9	642 (1)	878 (1)	684 (1)	512 (2)	688 (3)	–	–	–	–	–
9.0–9.9	–	–	845 (1)	701 (3)	790 (5)	855 (1)	903 (1)	–	–	–
10.0–10.9	–	–	960 (1)	828 (11)	1,102 (2)	840 (3)	–	835 (1)	–	–
11.0–11.9	–	–	–	–	838 (2)	898 (1)	863 (1)	–	–	908 (1)
12.0–12.9	–	–	–	–	1,075 (1)	981 (5)	–	795 (1)	–	–
13.0–13.9	–	–	–	–	–	–	1,120 (1)	–	–	–
14.0–14.9	–	–	–	–	–	825 (1)	1,043 (1)	1,199 (1)	1,136 (1)	–
15.0–15.9	–	–	–	–	–	–	1,055 (1)	1,029 (1)	–	–

opaque ova measuring at least 0.70 mm (Lewis, 1962). The quantity of mature ova in each sample was expressed as the number per gram of ovary.

After the preserved ovaries were drained of excess moisture, blotted, and weighed to the nearest 0.1 g, samples of ova were taken from the anterior, central, and posterior sections of each ovary, then covered in 90-mm Petri dishes to prevent dehydration. Approximately 1 g of each sample was removed and weighed on an analytical torsion balance to the nearest 0.001 g. The ova were then teased apart and the mature ones counted with the aid of a 3× desk magnifier–illuminator.

The mean numbers of mature ova per gram of ovary in samples from the three sections of each ovary were compared by analysis of variance. In material from each of the three study years, no significant differences were detected among sections of the same ovary or between the left and right ovaries. Thus, a single mean value, based on the three samples, was computed for each ovary. To estimate the total number of mature ova for each ovary, we multiplied the mean number of mature ova per gram by the total ovary weight. We then added the estimated number of ova from each ovary to obtain the total for each fish.

RELATION OF FECUNDITY TO BODY WEIGHT, FORK LENGTH, AND AGE

The mean number of mature ova in striped bass from the Roanoke River varied considerably by age-group, body weight, and fork length (Tables 1, 2, and 3). Morgan and Gerlach (1950) showed that striped bass in Oregon produced about 100,000 eggs per pound of body weight. In striped bass from

TABLE 2.—*Estimated mean number of mature ova (thousands) by age-group and fork length in striped bass from the Roanoke River, North Carolina, during April and May 1958, 1960, and 1963*
[Values in parentheses are the numbers of specimens upon which the mean values are based. These numbers do not total 159 because the weight of 1 fish and the lengths of 12 fish were not recorded. Sixteen fish could not be aged]

Fork length (inches)	Age-group									
	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
17.0–17.9	282 (1)	–	–	–	–	–	–	–	–	–
18.0–18.9	222 (7)	231 (1)	–	–	–	–	–	–	–	–
19.0–19.9	332 (8)	–	345 (1)	–	–	–	–	–	–	–
20.0–20.9	341 (26)	409 (4)	289 (1)	–	–	–	–	–	–	–
21.0–21.9	385 (15)	363 (2)	–	–	–	–	–	–	–	–
22.0–22.9	402 (5)	413 (5)	616 (3)	–	518 (1)	–	–	–	–	–
23.0–23.9	–	522 (2)	570 (1)	548 (1)	524 (1)	–	476 (1)	–	–	–
24.0–24.9	642 (1)	878 (1)	684 (1)	512 (2)	812 (3)	–	–	–	–	–
25.0–25.9	–	–	902 (2)	749 (6)	933 (3)	833 (3)	–	–	–	–
26.0–26.9	–	–	–	848 (7)	577 (1)	887 (2)	903 (1)	–	–	–
27.0–27.9	–	–	–	783 (1)	976 (4)	977 (3)	863 (1)	815 (2)	–	908 (1)
28.0–28.9	–	–	–	–	729 (1)	988 (2)	1,082 (2)	–	1,136 (1)	–
29.0–29.9	–	–	–	–	–	825 (1)	1,055 (1)	1,199 (1)	–	–
30.0–30.9	–	–	–	–	–	–	–	1,029 (1)	–	–

TABLE 3.—*Estimated mean number of mature ova (thousands) by body weight and fork length in striped bass from the Roanoke River, North Carolina, during April and May 1958, 1960, and 1963*

[Values in parentheses are the numbers of specimens upon which the mean values are based. These numbers do not total 159 because the weight of 1 fish and the lengths of 12 fish were not recorded. Sixteen fish could not be aged]

Fork length (inches)	Body weight (pounds)													
	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0–10.9	11.0–11.9	12.0–12.9	13.0–13.9	14.0–14.9	15.0–15.9
17.0–17.9	—	282 (1)	—	—	—	—	—	—	—	—	—	—	—	—
18.0–18.9	163 (3)	239 (4)	339 (1)	—	—	—	—	—	—	—	—	—	—	—
19.0–19.9	—	244 (4)	372 (6)	—	—	—	—	—	—	—	—	—	—	—
20.0–20.9	—	—	320 (23)	411 (10)	—	—	—	—	—	—	—	—	—	—
21.0–21.9	—	—	298 (2)	400 (15)	401 (1)	—	—	—	—	—	—	—	—	—
22.0–22.9	—	—	—	446 (3)	454 (8)	490 (3)	—	—	—	—	—	—	—	—
23.0–23.9	—	—	—	—	570 (1)	517 (4)	—	524 (1)	—	—	—	—	—	—
24.0–24.9	—	—	—	—	—	—	664 (6)	839 (2)	—	—	—	—	—	—
25.0–25.9	—	—	—	—	—	—	—	792 (7)	864 (7)	—	—	—	—	—
26.0–26.9	—	—	—	—	—	—	577 (1)	903 (1)	851 (8)	898 (1)	—	—	—	—
27.0–27.9	—	—	—	—	—	—	—	—	923 (3)	862 (4)	960 (5)	—	—	—
28.0–28.9	—	—	—	—	—	—	729 (1)	—	—	—	988 (2)	959 (2)	1,090 (2)	—
29.0–29.9	—	—	—	—	—	—	—	—	—	—	—	—	1,012 (2)	1,055 (1)
30.0–30.9	—	—	—	—	—	—	—	—	—	—	—	—	—	1,029 (1)

Chesapeake Bay, Jackson and Tiller (1952) found more eggs per pound of body weight in older fish than in younger ones. For every pound of body weight, ovaries from these fish contained from 62,000 to 112,000 eggs. Our study yielded a value of approximately 80,000.

We examined for curvilinearity the relation of total number of mature ova per fish to body weight, fork length, and age. The regressions of total number of mature ova on body weight and on fork length were linear.[1] Similarly, the number of mature ova as a function of age increased linearly to age-group IX, then began to curve. Subsequent analysis was limited to the linear data. The regressions for each feature did not differ significantly among the 3 years; therefore, the data for each relation were pooled.

We also examined the data to determine which relationship had the least variability. In general, the coefficient of variation of any sample estimate is equal to the standard error of estimate divided by the value being estimated and, accordingly, is a measure of relative variation. In a bivariate distribution, $f(x, y)$, the coefficient of variation of the regression of Y on X is

$$\mathrm{CV}\ (b) = \frac{\sqrt{s^2/\Sigma x^2}}{b},$$

where: $s^2 = \dfrac{\Sigma y^2 - b\,\Sigma xy}{n-2}$ and b is the estimated regression coefficient.

Comparison of these coefficients for the regressions of egg number on age, length, and weight, viz.,

$$\mathrm{CV}\ (b)\ \text{age} = 0.0604$$

$$\mathrm{CV}\ (b)\ \text{length} = 0.0414, \text{ and}$$

$$\mathrm{CV}\ (b)\ \text{weight} = 0.0366,$$

[1] The apparent straight-line relationship between ova number (a volume function) and fish length (a linear function) would appear questionable. Among the specimens examined, however, variability of the measurement data masked expected curvilinearity and therefore prompted our use of the simpler linear regression technique.

indicated that of the three suggested predictors, weight had associated with it the least amount of variability. For prediction we therefore computed a simple linear regression of egg count (Y) on weight (X) (Figure 1). The equation for estimating number of ova ($\hat{Y}$) is:

$$\hat{Y} = \bar{y} + b(X - \bar{x}) = 555{,}182 + 75{,}858(X - 7.3)$$

and the 95% confidence interval for the mean egg count of all fish at a given weight (X) is:

$$\text{CI } (\hat{Y}) = \hat{Y} \pm 24.19\sqrt{0.0063 + \frac{(X - 7.3)^2}{1{,}770}}\,.$$

This relationship, in conjunction with measures of population size and sex ratio, permits estimation of the approximate number of mature ova that a spawning population can produce.

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ROBERT M. LEWIS
RUPERT R. BONNER, JR.

U. S. Bureau of Commercial Fisheries
Biological Laboratory
Beaufort, North Carolina